On the chromospheric activity of stars with planets

B. L. Canto Martins, M. L. das Chagas, S. Alves, I. C. Leão, L. P. de Souza Neto, and J. R. de Medeiros

Departamento de Física, Universidade Federal do Rio Grande do Norte, Natal, Brazil

ABSTRACT

Context. Signatures of chromospheric activity enhancement have been found for a dozen stars, pointing to a possible star-planet interaction. Nevertheless in the coronal activity regime, there is no conclusive observational evidence for such an interaction. Does star-planet interaction manifest itself only for a few particular cases, without having a major effect on stars with planets in general?
Aims. We aim to add additional observational constraints to support or reject the major effects of star-planet interactions in stellar activity, based on CaII chromospheric emission flux.
Methods. We performed a statistical analysis of CaII emission flux of stars with planets, as well as a comparison between CaII and X-ray emission fluxes, searching for dependencies on planetary parameters.
Results. In the present sample of stars with planets, there are no significant correlations between chromospheric activity indicator $\log(R'_{HK})$ and planetary parameters. Further, the distribution of the chromospheric activity indicator for stars without planets is not distinguishable from the one with planets.

Key words. Planet–star interaction – Stars: activity – Stars: Chromosphere – Stars: coronae – Stars: statistics

1. Introduction

Since the pioneering discovery by Michel Mayor and Didier Queloz (1995), a little more than a decade ago, of a planet orbiting the star *51 Peg*, more than 450 other exoplanets have been found at the time of writing (e.g.: Schneider 2010). The discovered planets have masses ranging from 4 Earth masses to 11 Jupiter masses. They can be found at distances of several AU or close to the parent star, with orbital periods ranging from a few days to a few years. High eccentricity is a common parameter connecting these planets (e.g.: Marcy et al. 2001).

These discoveries have inspired intensive studies on the physical properties of the planets and of their parent stars, including a possible star-planet interaction. Indeed, in an analogy to binary stars, which show a higher activity level compared to single stars, at very close distances, one might also expect planets to play a role in the level of activity of their host stars. Nevertheless, observational data, yet at a very informative level, demonstrate that star-planet interaction appears to be more complex than the widely accepted star-star interaction in close binary systems. For instance, Shkolnik et al. (2003, 2008) reported a planet-induced chromospheric activity on two stars with planets, HD 179949 and υ *And*, apparent from the night-to-night modulation of the CaII H and K chromospheric emission phased with the hot Jupiter's orbit. In addition, Kashyap et al. (2008) claimed that stars with close-in giant planets are on average more X-ray active than those with planets that are more distant, an observational result consistent with the hypothesis that giant planets in close proximity to the parent stars could influence stellar magnetic activity.

By contrast, Poppenhaeger et al. (2010) found no significant correlations between X-ray luminosity and planetary parameters, suggesting no major average activity enhancement in the corona of stars with planets. Indeed, these authors found no additional detectable effects in coronal X-ray luminosity that could be associated to coronal manifestations of star-planet interaction. According to Poppenhaeger et al. (2010), any trends in the X-ray luminosity versus planet orbital parameters seem to be dominated by selection effects. In addition, Fares et al. (2010) reported no clear evidence of star-planet magnetospheric interactions in HD 189733. In this context, let us recall that more recently, from a comparison of the distribution of the rotation of stars with and without detected planets, Alves et al. (2010) showed that the $v \sin i$ distribution for these two families of stars is drawn from the same population distribution function.

Because the observational basis of stellar activity enhancement due to star-planet interaction is, clearly, not yet established, in the present study we report a statistical analysis of stellar CaII chromospheric emission flux for a sample of 74 stars with planets, as described in the following sections. For a more solid analysis of the behavior of chromospheric and coronal activity of stars with planets, it is essential to conduct a comparative analysis of stars without detected planets. This is one of the major goals of the current study. In this context, we also analyzed the CaII chromospheric emission flux of a comparison sample of 26 stars without detected planets. The paper is organized as follows: in Section 2 we present the characteristics of the working samples, in Section 3 we describe our findings, with a brief discussion and finally, we outline our conclusions in Section 4.

2. Stellar working sample and data

Different methods, such as radial velocity measurements (Butler et al. 1996; de Medeiros et al. 2009), and photometric light curves (Konacki et al. 2003, 2004), have been used to discovery the existence of new planetary systems around other stars than the Sun. Aiming to make our sample homogeneous, we use
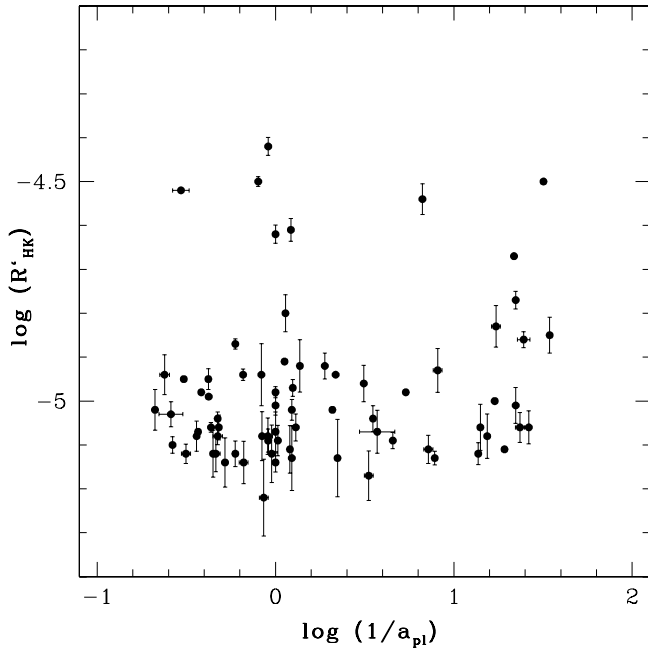
Fig. 1. Chromospheric activity indicator $\log(R'_{HK})$ as a function of the planetary semi-major axis $\log(1/a_{pl})$ for our sample of stars with planets.

Fig. 2. Chromospheric activity indicator $\log(R'_{HK})$ as a function of the product of the planetary mass with the reciprocal semi-major axis $\log(1/a_{pl} \times M_{pl})$ for our sample of stars with planets.

only stars that had their planets discovered using radial velocity method.

The present stellar working sample consists of selected objects from the base of extrasolar planets maintained by Jean Schneider (Schneider 2010), updated on October 6, 2009, when there were 235 planets cataloged by the method of variation of the radial velocity (RV). We checked which of these stars presented Ca II emission flux detected in the catalog of Wright et al. (2004). After this selection, we filtered the complete stellar sample to obtain a subset of main-sequence stars that are within 20 pc in the solar neighborhood. Our final working sample consists of 74 stars with planets with spectral types in the F-G-K interval, as presented in Table 1.

The chromospheric activity indicator, $\log(R'_{HK})$, for all stars was computed from the Ca II H and K line-core emission index listed by Wright et al. (2004), following the procedure of converting emission index S to the flux at the stellar surface proposed by Noyes et al. (1984). To diagnose coronal activity of the stars forming the above mentioned stellar sample, we used the coronal activity indicator, $\log(\frac{L_X}{L_{bol}})$, that was computed using the X-ray fluxes listed by Kashyap et al. (2008) and Poppenhaeger et al. (2010). Readers are referred to these works for a discussion of the observational procedures, data reduction and error analysis.

Stellar luminosities were determined as follows: first, apparent visual magnitudes (m_v) and trigonometric parallaxes, both taken from the HIPPARCOS catalogue (ESA 1997), were combined to yield the absolute visual magnitude (M_v). Bolometric correction (BC), computed from Flower (1996) calibration, was applied to obtain the bolometric magnitude, which was finally converted into stellar luminosity. The effective temperature was computed using Flower (1996) ($B - V$) versus T_{eff} calibration. The stellar and planetary parameters, as well as chromospheric and coronal activity indicators for the entire sample of stars with planets, are listed in Table 1.
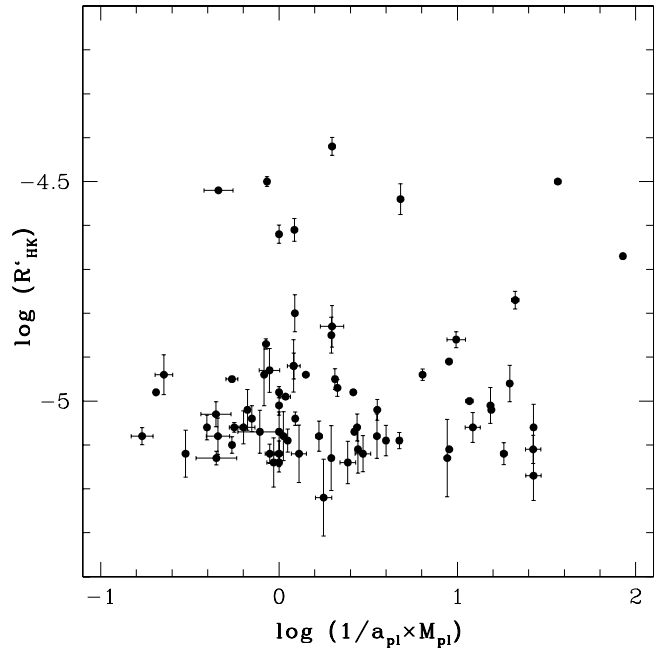
For comparative purposes, we took a sample of stars not known to have any planetary-mass companions. This new sample was taken from Schmitt et al. (1997), as done by Poppenhaeger et al. (2010), and is composed of 26 F-G-K type dwarf stars with all stars having Ca II emission flux measured by Wright et al. (2004) and X-ray fluxes detected by Schmitt (1997). The chromospheric and coronal activity indicators were calculated as before for the sample of stars with planets. However, we should be cautious about this sample, which derives from a list of stars that are surveyed for planets, but for which none have yet been found. This certainly does not mean that such stars have no planetary companions whatsoever. In fact, they might host planets with very low mass and/or a long orbital period that are more difficult to detect with radial velocity surveys. Stellar properties, as well as chromospheric and coronal activity indicators for stars without detected planets are given in Table 2.

3. Results and discussion

The aim of this work is to point out additional observational constraints to support or reject major effects of star-planet interaction in stellar activity, based on CaII chromospheric and X-ray emission fluxes. To this end, we dedicated most of our efforts to identifying qualitative trends between CaII and X-ray fluxes and planetary parameters. We chose $\log(R'_{HK})$ and $\log(\frac{L_X}{L_{bol}})$ as indicators of chromospheric and coronal activity, respectively, because they are independent of stellar radius-induced effects. Indeed, it is expected that any planet-induced activity changes should therefore be more evident in $\log(\frac{L_X}{L_{bol}})$ (e.g.: Poppenhaeger et al. 2010). In the context of any planet-induced chromospheric activity, one should also expect more evident changes in $\log(R'_{HK})$ for such an aspect.
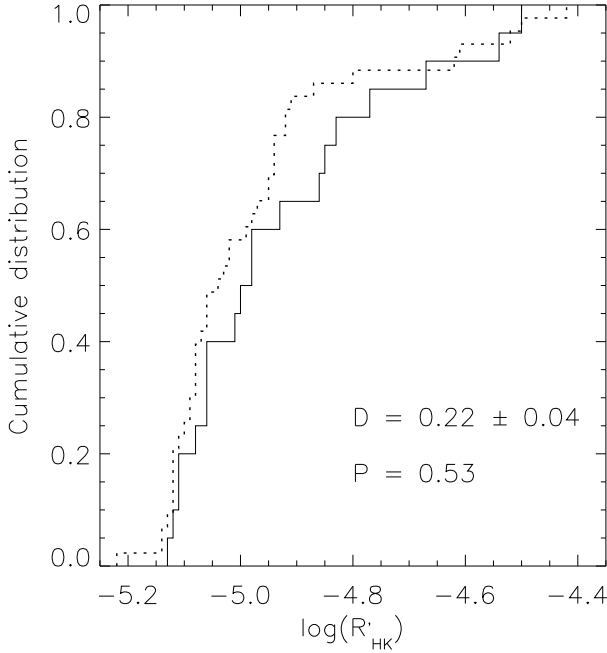
Following the same strategy used by Poppenhaeger et al. (2010) in their analysis of the coronal X-ray emission behav-

Table 1. Stellar and planetary parameters and chromospheric and coronal activity indicators of stars with planets (**Sources:** a - Kashyap et al. (2008); b Poppenhaeger et al. (2010)).

Star	ST	$(B-V)$	a_{pl}	M_{pl}	$\log(R'_{HK})$	$\log(\frac{L_X}{L_{bol}})^a$	$\log(\frac{L_X}{L_{bol}})^b$
HD 3651	K0V	0.850 ± 0.009	0.284	0.200	-5.04 ± 0.03	-6.07 ± 0.08	-6.07 ± 0.23
HD 4203	G5	0.771 ± 0.021	1.164 ± 0.07	2.070 ± 0.18	-5.22 ± 0.09	-5.18 ± 0.22	
HD 4208	G5V	0.664 ± 0.004	0.800	1.700	-4.97 ± 0.02	-5.12	
HD 7924	K0	0.826 ± 0.006	0.029	0.057	-4.85 ± 0.04		-5.71 ± 0.29
HD 8574	F8	0.577 ± 0.011	0.770	2.110	-5.06 ± 0.03	-5.00	
HD 10697	G5IV	0.720 ± 0.009	2.160 ± 0.12	6.380 ± 0.53	-5.12 ± 0.04	-5.83 ± 0.17	
HD 12661	K0	0.710 ± 0.015	0.830	2.300	-5.11 ± 0.05	-5.44	
HD 16141	G5IV	0.670 ± 0.004	0.350	0.215 ± 0.03	-5.14 ± 0.02	-5.32	
HD 19994	F8V	0.575 ± 0.005	1.680	1.420	-4.87 ± 0.01	-6.04	-6.01 ± 0.28
HD 20367	G0	0.574 ± 0.008	1.250	1.070	-4.50 ± 0.01	-4.54 ± 0.03	-4.42 ± 0.12
HD 23596	F8	0.634 ± 0.009	2.720	7.190	-5.07		-5.34
HD 30562	F8V	0.631 ± 0.003	2.300 ± 0.02	1.290 ± 0.08	-5.06 ± 0.01		-7.08
HD 37124	G4IV-V	0.667 ± 0.008	0.529 ± 0.00	0.640 ± 0.05	-4.92 ± 0.03	-5.15	
HD 40979	F8	0.573 ± 0.007	0.811	3.280 ± 3.00	-4.62 ± 0.02	-5.51	
HD 45350	G5	0.740 ± 0.015	1.920 ± 0.07	1.790 ± 0.14	-5.14 ± 0.06	-5.11	
HD 46375	K1IV	0.860 ± 0.000	0.041	0.249 ± 0.03	-4.98 ± 0.01	-6.02 ± 0.08	
HD 49674	G0	0.729 ± 0.015	0.058 ± 0.00	0.115 ± 0.02	-4.83 ± 0.05	-5.02	
HD 50499	G1V	0.614 ± 0.008	3.860 ± 0.60	1.710 ± 0.20	-5.03 ± 0.03	-4.98	
HD 50554	F8	0.582 ± 0.008	2.380	4.900	-4.95 ± 0.02	-6.81	
HD 52265	G0III-IV	0.572 ± 0.003	0.490	1.050 ± 0.03	-5.01 ± 0.02	-5.60	-6.65 ± 0.17
HD 66428	G5	0.715 ± 0.002	3.180 ± 0.19	2.820 ± 0.03	-5.12 ± 0.02	-4.87	
HD 68988	G0	0.652 ± 0.015	0.071	1.900	-5.06 ± 0.05	-4.93	
HD 69830	K0V	0.754 ± 0.009	0.186	0.038	-4.98	-5.89 ± 0.15	-5.89 ± 0.30
HD 72659	G0	0.612 ± 0.015	4.740 ± 0.08	3.150 ± 0.01	-5.02 ± 0.05	-5.16	
HD 74156	G0	0.585 ± 0.014	0.294	1.880	-5.07 ± 0.05	-5.26	
HD 80606	G5	0.765 ± 0.025	0.449 ± 0.01	3.940 ± 0.11	-5.13 ± 0.09	-4.82	
HD 82943	G0	0.623 ± 0.001	0.730	0.880	-4.92 ± 0.06	-5.76	-5.76
HD 83443	K0V	0.811 ± 0.003	0.041 ± 0.00	0.400 ± 0.03	-4.86 ± 0.02	-4.96	
HD 89307	G0V	0.594 ± 0.003	3.270 ± 0.07	1.780 ± 0.13	-4.95	-5.60	
HD 89744	F7V	0.531 ± 0.003	0.890	7.990	-4.91	-6.31 ± 0.07	
HD 92788	G5	0.694 ± 0.005	0.970	3.860	-5.09 ± 0.03	-5.53	
HD 99109	K0	0.874 ± 0.002	1.105 ± 0.07	0.502 ± 0.07	-5.08 ± 0.04	-5.13	
HD 99492	K2V	1.002 ± 0.012	0.123 ± 0.01	0.109 ± 0.01	-4.93 ± 0.05	-5.55 ± 0.18	-6.13 ± 0.16
HD 106252	G0	0.635 ± 0.007	2.610	6.810	-4.98	-6.03	
HD 107148	G5	0.707 ± 0.013	0.269 ± 0.06	0.210 ± 0.04	-5.07 ± 0.05	-5.35	
HD 108874	G5	0.738 ± 0.018	1.051 ± 0.02	1.360 ± 0.13	-5.12 ± 0.07	-5.14	
HD 114729	G0V	0.591 ± 0.008	2.080	0.820	-5.06 ± 0.03	-5.66	
HD 114783	K0	0.930 ± 0.013	1.200	0.990	-4.94 ± 0.07	-5.49	-6.60 ± 0.19
HD 117207	G8IV/V	0.724 ± 0.002	3.780	2.060	-5.10 ± 0.02	-5.47	
HD 128311	K0	0.973 ± 0.004	1.099 ± 0.04	2.180 ± 0.02	-4.42 ± 0.02	-4.54 ± 0.06	-4.54 ± 0.21
HD 130322	K0III	0.781 ± 0.002	0.880	1.080	-4.80 ± 0.04	-5.69 ± 0.07	-5.66 ± 0.16
HD 134987	G5V	0.691 ± 0.020	0.810 ± 0.02	1.590 ± 0.02	-5.13 ± 0.07	-5.78	-5.78
HD 141937	G2/G3V	0.628 ± 0.002	1.520	9.700	-4.94 ± 0.01	-5.39	
HD 150706	G0	0.607 ± 0.005	0.820	1.000	-4.61 ± 0.03	-4.68 ± 0.04	-4.68 ± 0.19
HD 154345	G8V	0.728 ± 0.005	4.190 ± 0.26	0.947 ± 0.09	-4.94 ± 0.05	-5.59	-6.02 ± 0.16
HD 164922	K0V	0.799 ± 0.005	2.110 ± 0.13	0.360 ± 0.05	-5.08 ± 0.02	-5.49	-6.60
HD 168443	G5	0.724 ± 0.014	0.300 ± 0.02	8.020 ± 0.65	-5.17 ± 0.06	-5.50	
HD 168746	G5	0.713 ± 0.015	0.065	0.230	-5.08 ± 0.05	-4.96	
HD 169830	F8V	0.517 ± 0.004	0.810	2.880	-5.02 ± 0.02	-6.10 ± 0.04	
HD 170469	G5	0.677 ± 0.014	2.240	0.670	-5.12 ± 0.05	-3.01	
HD 178911B	G1V	0.643 ± 0.007	0.320	6.292 ± 0.06	-4.96 ± 0.04	-5.56 ± 0.18	
HD 179949	F8V	0.548 ± 0.009	0.045 ± 0.00	0.950 ± 0.04	-4.77 ± 0.02	-5.25 ± 0.10	-5.25 ± 0.25
HD 183263	G2IV	0.678 ± 0.012	1.510 ± 0.09	3.670 ± 0.30	-5.14 ± 0.05	-4.72	
HD 187123	G5	0.661 ± 0.010	0.043 ± 0.00	0.520 ± 0.04	-5.06 ± 0.03	-6.40	
HD 188015	G5IV	0.727 ± 0.010	1.190	1.260	-5.08 ± 0.06	-4.78	
HD 189733	G5	0.932 ± 0.008	0.031 ± 0.00	1.150 ± 0.04	-4.50	-4.74 ± 0.14	-4.91 ± 0.19
HD 190360	G6IV+...	0.749 ± 0.001	0.128 ± 0.00	0.057 ± 0.02	-5.13 ± 0.02	-6.71	-7.45 ± 0.21
HD 192263	K0	0.938 ± 0.015	0.150	0.720	-4.54 ± 0.04	-5.06 ± 0.20	-5.06 ± 0.35
HD 195019	G3IV-V	0.662 ± 0.007	0.139 ± 0.01	3.700 ± 0.30	-5.11 ± 0.03	-7.51 ± 0.17	-7.42 ± 0.17
HD 196885	F8IV:	0.559 ± 0.006	2.370 ± 0.02	2.580 ± 0.16	-4.99	-5.59	
HD 209458	F8	0.594 ± 0.015	0.045 ± 0.00	0.690 ± 0.02	-5.01 ± 0.04	-6.77 ± 0.20	
HD 210277	G0	0.773 ± 0.006	1.100 ± 0.02	1.230 ± 0.03	-5.09 ± 0.03	-5.74	-5.74
HD 216770	K0V	0.821 ± 0.004	0.460	0.650	-4.94	-4.95	
HD 217107	G8IV	0.744 ± 0.006	0.073 ± 0.00	1.330 ± 0.05	-5.12 ± 0.02	-6.15 ± 0.16	-6.81
14 *Her*	K0V	0.877 ± 0.006	2.770 ± 0.05	4.640 ± 0.19	-5.08 ± 0.03	-6.13	-6.34 ± 0.14
16 *Cyg*	G2V	0.643 ± 0.006	1.680 ± 0.03	1.680 ± 0.07	-5.12 ± 0.03	-5.90	-7.33

Table 1. Cont.

Star	ST	$(B-V)$	a_{pl}	M_{pl}	$\log(R'_{HK})$	$\log(\frac{L_X}{L_{bol}})^a$	$\log(\frac{L_X}{L_{bol}})^b$
47 *UMa*	G0V	0.624 ± 0.003	2.110 ± 0.02	2.600 ± 0.07	-5.04 ± 0.02	-6.66 ± 0.04	-7.39 ± 0.21
51 *Peg*	G5V	0.666 ± 0.007	0.052	0.468 ± 0.01	-5.11	-6.91 ± 0.09	-7.43 ± 0.18
55 *Cnc*	G8V	0.869 ± 0.012	0.038 ± 0.00	0.024 ± 0.00	-5.06 ± 0.04	-6.37 ± 0.11	-6.32 ± 0.14
70 *Vir*	G5V	0.714 ± 0.007	0.480	7.440	-5.02	-6.64 ± 0.13	-6.64 ± 0.28
ϵ *Eri*	K2V	0.881 ± 0.007	3.390 ± 0.36	1.550 ± 0.24	-4.52	-4.99 ± 0.00	-4.89 ± 0.12
ρ *CrB*	G2V	0.612 ± 0.003	0.220	1.040	-5.09 ± 0.02	-6.13	-6.13
τ *Boo*	F7V	0.508 ± 0.001	0.046	3.900	-4.67	-5.29 ± 0.02	-5.18 ± 0.12
υ *And*	F8V	0.536 ± 0.007	0.059 ± 0.00	0.690 ± 0.03	-5.00	-6.00 ± 0.07	-6.00 ± 0.22

Fig. 3. The cumulative distributions of $\log(R'_{HK})$ for stars with $a_{pl} \leq 0.2$ AU (solid curve) and $a_{pl} \geq 0.5$ AU (dashed curve).

Table 2. Stellar parameters and chromospheric and coronal activity indicators for the sample of stars without planets (Schmitt 1997).

Star	ST	$(B-V)$	$\log(R'_{HK})$	$\log(\frac{L_X}{L_{bol}})$
HD 4614	G0V...	0.587 ± 0.003	-4.93 ± 0.01	-6.59
HD 10700	G8V	0.727 ± 0.007	-5.01 ± 0.02	-6.55
HD 13974	G0V	0.607 ± 0.005	-4.71 ± 0.01	-5.13
HD 14412	G8V	0.724 ± 0.003	-4.89 ± 0.04	-6.13
HD 14802	G2V	0.608 ± 0.017	-5.06 ± 0.07	-5.06
HD 16895	F7V	0.514 ± 0.002	-4.92	-6.12
HD 19373	G0V	0.595 ± 0.007	-5.01 ± 0.02	-6.83
HD 30495	G3V	0.632 ± 0.006	-4.61	-4.75
HD 30652	F6V	0.484 ± 0.003	-4.60	-5.03
HD 69830	K0V	0.754 ± 0.009	-4.98	-5.85
HD 72673	K0V	0.780 ± 0.010	-4.98 ± 0.04	-5.84
HD 90839	F8V	0.541 ± 0.008	-4.83	-5.53
HD 101501	G8Vvar	0.723 ± 0.014	-4.57	-5.04
HD 102870	F8V	0.518 ± 0.015	-4.90	-5.85
HD 103095	G8Vp	0.754 ± 0.009	-4.88 ± 0.02	-6.48
HD 104304	K0IV	0.760 ± 0.021	-4.95	-6.09
HD 109358	G0V	0.588 ± 0.009	-4.92 ± 0.03	-6.44
HD 114710	G0V	0.572 ± 0.006	-4.75	-5.58
HD 115617	G5V	0.709 ± 0.007	-5.07	-6.53
HD 117176	G5V	0.714 ± 0.007	-5.02	-7.66
HD 131156	G8V+...	0.720 ± 0.015	-4.37	-4.62
HD 141004	G0Vvar	0.604 ± 0.008	-4.98 ± 0.02	-6.05
HD 142860	F6V	0.478 ± 0.006	-4.76	-6.49
HD 144579	G8V	0.734 ± 0.001	-5.00 ± 0.01	-6.19
HD 161797	G5IV	0.750 ± 0.015	-5.15 ± 0.06	-6.32
HD 185144	K0V	0.786 ± 0.007	-4.88 ± 0.06	-5.81

ior in stars with planets, we show the distribution of the chromospheric activity indicator $\log(R'_{HK})$ of stars with planets as a function of planetary distance $\log(1/a_{pl})$ (Fig. 1). A close comparison of the distribution of $\log(R'_{HK})$ versus $\log(1/a_{pl})$ with the distribution of the coronal activity indicator $\log(\frac{L_X}{L_{bol}})$ versus $\log(1/a_{pl})$, illustrated in Fig. 5 of Poppenhaeger et al. (2010), shows that, at least qualitatively, the behavior of the chromospheric activity indicator appears to be comparable to that of the coronal activity indicator. The same aspect can be seen in Fig. 2 were we show the distribution of the chromospheric activity indicator $\log(R'_{HK})$ of stars with planets as a function of the product of the planetary mass with the reciprocal distance $\log(1/a_{pl})$.

In addition, still following the strategy proposed by Poppenhaeger et al. (2010), we carried out a statistical analysis of both $\log(R'_{HK})$ and $\log(\frac{L_X}{L_{bol}})$ activity indicators, of stars with close-in planets, namely planets with $a_{pl} \leq 0.20$ AU, searching for correlations with planetary mass and semi-major axis. Table 3 shows the result of such an analysis, with the Spearman's ρ rank correlation for various combinations of stellar quantities and planetary parameters, for two sample: the first is composed of 19 stars with X-ray lumisonity from Kashyap et al. (2008), and the second one is composed of 13 stars with X-ray luminosities from Poppenhaeger et al. (2010). The first interesting aspect from this analysis is a possible anticorrelation between the chro-

mospheric activity indicator and the planetary semi-major axis in stars hosting planets with $a_{pl} \leq 0.20$ AU for both samples. When we consider the entire sample of stars, we observe an absence of any significant correlation between these two parameters, without discrimination of a_{pl} values.

Two possible correlations are found in the present analysis: One of planetary mass $\log(M_{pl})$ with $\log(R'_{HK})$ and the other of product of the planetary mass with the reciprocal distance $\log(1/a_{pl} \times M_{pl})$ with $\log(R'_{HK})$. Stars with giant and close-in planets exhibit higher $\log(R'_{HK})$ values than those with small outermost planets, a result corroborating that obtained by Poppenhaeger et al. (2010) for the relationship between X-ray luminosities and planetary parameters. In this context, the Spearman coefficients from the correlation study of $\log(R'_{HK})$ with $\log(\frac{L_X}{L_{bol}})$, also displayed in Table 3, show a significant correlation between chromospheric and coronal activity indicators for stars with close-in planets. This correlation indicates that the relations found by Poppenhaeger et al. (2010) between the coronal activity indicator and the planetary parameters must be the

Table 3. Statistical analysis of chromospheric activity indicator $\log(R'_{HK})$ and planetary parameters and between coronal activity indicator $\log(\frac{L_X}{L_{bol}})$ for stars with planets with semi-major axis $a_{pl} \leq 0.2$ AU for two sample: one composed of 19 stars with X-ray lumisonity from Kashyap et al. (2008), and other composed of 13 stars with X-ray luminosities from Poppenhaeger et al. (2010).

Parameters	Spearman's ρ	Probability p	Spearman's ρ	Probability p
	(Kashyap et al. 2009)		(Poppenhaeger et al. 2010)	
$\log R'_{HK}$ with $\log \mathbf{a_{pl}}$	-0.26±0.06	0.30±0.12	-0.29±0.06	0.34±0.10
$\log R'_{HK}$ with $\log M_{pl}$	0.13±0.07	0.61±0.19	0.20±0.08	0.52±0.16
$\log R'_{HK}$ with $\log 1/a_{pl} \times M_{pl}$	0.17±0.06	0.51±0.17	0.32±0.06	0.29±0.09
$\log R'_{HK}$ with $\log \frac{L_X}{L_{bol}}$	0.64±0.09	0.008±0.015	0.92±0.04	$5.0\times10^{-5}\pm2\times10^{-4}$

Fig. 4. Chromospheric activity indicator $\log(R'_{HK})$ as a function of colour index $(B - V)$. Open circles denote stars with planets and solid circles stars without planets.

Fig. 5. The cumulative distributions of $\log(R'_{HK})$ for stars with planets (solid curve) and stars without planets (dashed curve). For the sample of stars hosting planets, we are only considering stars with planets with $a_{pl} \leq 0.20$ AU.

same obtained in our analysis of stellar chromospheric activity and the presence of planets around a star.

As an additional statistical test to verify if the present data sets, seggregated by planetary distances, are signicantly different from one another, we applied the Kolmogorov-Smirnov test (Press et al. 1992), which calculates the probability that two distributions are derived from the same parent distribution. According to the K-S test, the p value indicates the probability that both distributions come from the same origin. We conducted a K-S analysis, taking into account the $\log(R'_{HK})$ of stars with planets within $a_{pl} \leq 0.20$ AU (20 stars) and stars with planets beyond $a_{pl} \geq 0.50$ AU (43 stars), once again following the strategy adopted by Poppenhaeger et al. (2010). Fig. 3 shows the cumulative functions for both $\log(R'_{HK})$ distributions. The errors were calculated considering the errors in $log(R'_{HK})$ by applying random fluctuations with Gaussian distribution. The final values of D are the average of the standard deviation after the application of the fluctuations. The probability value of about 53% obtained on the K-S test is consistent with the two distributions being drawn from the same population. In agreement with Poppenhaeger et al. (2010), in their analysis of coronal X-ray emission, the present result indicates that both distributions of
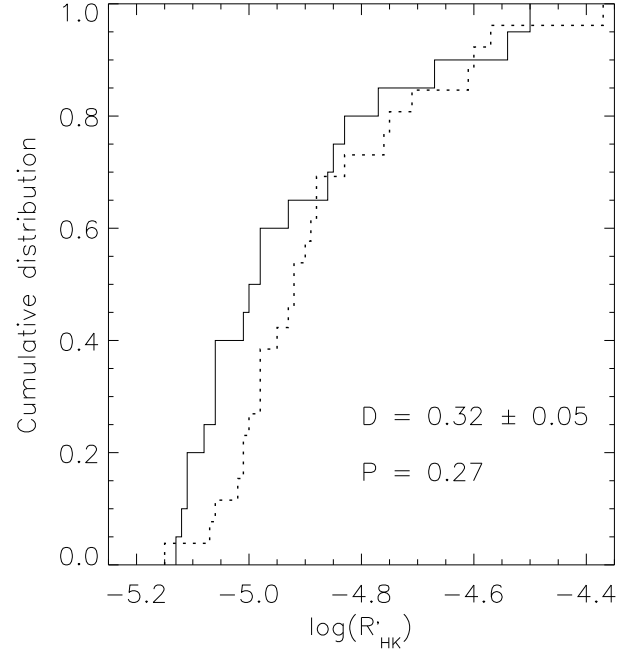
chromospheric activity indicator $\log(R'_{HK})$ of stars with close-in and far-out planets are very similar.

3.1. Comparison of chromospheric activity indicator in stars with and without planets

In a search for systematic differences, we compared the behavior of chromospheric activity indicator $\log(R'_{HK})$ in stars with and without detected planets. In Fig. 4 we show $\log(R'_{HK})$ versus colour index $(B - V)$ for both samples of stars, with no discernible differences. Both samples tend to follow the well known behavior of $\log(R'_{HK})$, characterized by a decreasing of chromospheric activity with increasing color index. In addition, in order to check for systematic differences between stars with and without detected planets, we compared the distributions of $\log(R'_{HK})$ for the two aforementioned samples, considering only stars hosting close-in planets, in other words, stars with planets with $a_{pl} \leq 0.20$ AU. Fig. 5 shows the cumulative functions for both distributions. A K-S test revels that the probability of both samples being drawn from the same parent distribution is 27%, reinforcing the previous scenario, which shows no clear evidence of enhanced chromospheric activity associated to the presence of planetary companions.

4. Conclusions

We analyzed a sample of 74 stars with planets in the solar neighborhood, presenting chromospheric activity indicator $\log(R'_{HK})$, searching for possible effects of star-planet interaction on the stellar chromosphere. From these analysis, we found no signicant correlations between the chromospheric activity indicator $\log(R'_{HK})$ and planetary parameters: semi-major axis and product of the planetary mass with the reciprocal semi-major axis. However, we found a possible correlation between the $\log(R'_{HK})$ and mass and between the product of planetary mass and reciprocal semi-major axis, indicating that massive close-in planets are often found around stars with an enhanced chromospheric activity indicator. Such a result supports that obtained by Poppenhaeger et al. (2010) in their analysis of X-ray coronal luminosity in stars with planets. According to these authors, this dependence can be ascribed to selection effects, since the Doppler method for planet detection favors small and far–out planets around stars with low activity. Indeed, the present analysis shows a strong correlation between chromospheric and coronal activity indicators of stars with planets. Additionally, a statistical comparison between the $\log(R'_{HK})$ indicator in stars with and without detected planets shows no clear evidence of enhanced chromospheric activity associated to the presence of planetary companions. In summary, our analysis reveal no clear evidence of enhanced planet-induced activity in the chromosphere of the stars. In agreement with the conclusions drawn by Poppenhaeger et al. (2010) in their analysis of the X-ray luminosity behavior of stars with planets, any trends observed in the present study seem to be mostly the result of selection effects.

References

Alves, S., do Nascimento, J. D., Jr, de Medeiros, J. R. 2010, MNRAS, 408, 1770
Butler, R. P., Marcy, G. W. 1996, ApJ, 464, 153
de Medeiros, J. R., Setiawan, J., Hatzes, A. P. et al. 2009, A&A 504, 617
ESA 1997, *The Hipparcos and Tycho Catalogues*, ESA SP-1200
Fares, R., Donati, J. -F., Moutou, C. et al. 2010, MNRAS, 406, 409
Flower, P. J. 1996, ApJ, 469, 355
Jetsu, L., Pelt, J. 1996, A&AS, 118, 58
Kashyap, V. L., Drake, J. J., Saar, S. H. 2008, ApJ, 687, 1339
Konacki, M., Torres, G., Jha, S., Sasselov, D. D. 2003, Nature, 421, 507
Konacki, M., Torres, G., Sasselov, D. D. et al. 2004, ApJ, 609, 37
Marcy G. W., Butler R. P., Fischer D., et al. 2001, ApJ, 556, 296
Mayor, M. & Queloz, D. 1995, Nature, 378, 355
Noyes, R. W., Hartmann, L. W., Baliunas, S. L., Duncan, D. K., Vaughan, A. H. 1984, ApJ, 279, 763
Paltani, S. 2004, A&A, 420, 789
Press W. H., Teukolsky S. A., Vetterling W. T., Flannery B. P. 1992, *Numerical Recipes in FORTRAN*. Cambridge Univ. Press, Cambridge
Poppenhaeger, K., Robrade, J., Schmitt, J. H. M. M. 2010, A&A, 515, 98
Schmitt, J. H. M. M. 1997, A&A, 318, 215
Schneider, J. 2010, The Extrasolar Planets Encyclopaedia. *Web Resource: http://exoplanet.eu*
Shkolnik, E., Walker, G. A. H., Bohlender, D. A. 2003, ApJ, 597, 1092
Shkolnik, E., Bohlender, D. A., Walker, G. A. H., Collier Cameron, A. 2008, ApJ, 676, 628
Wright, J. T., Marcy, G. W., Butler, R. P., Vogt, S. S. 2004, ApJS, 152, 261